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UNITED STATES PATENT APPLICATION

FOR

APPARATUS FOR DRYING A TISSUE WEB

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APPARATUS FOR DRYING A TISSUE WEB

Background of the Invention

In the manufacture of high-bulk tissue products, such as facial tissue, bath tissue, paper towels, and the like, it is common to use one or more throughdryers for partially drying the web or to bring the tissue web to a final dryness or near-final dryness. Generally speaking, throughdryers typically include a rotating cylinder having an upper deck that supports a drying fabric which, in turn, supports the web being dried. In particular, heated air is passed through the web in order to dry the web. For example, in one embodiment, heated air is provided by a hood above the drying cylinder. Alternatively, heated air is provided to a center area of the drying cylinder and passed through to the hood.

When incorporated into a papermaking system, throughdryers offer many and various benefits and advantages. For example, throughdryers are capable of drying tissue webs without compressing the web. Thus, moisture is removed from the webs without the webs losing a substantial amount of bulk or caliber. In fact, throughdryers, in some applications, may even serve to increase the bulk of the web. Throughdryers are also known to contribute to various other important properties and characteristics of the webs.

The use of throughdryers, however, can be expensive. For instance, in addition to the capital costs associated with the equipment, throughdryers have relatively high energy requirements. Therefore, a need currently exists for a system and process for reducing the energy costs associated with throughdryers, while still retaining all the benefits and advantages to using throughdryers.

In this regard, in the past, those skilled in the art have attempted to prevent the heated air used to dry tissue webs from leaking out of the throughdryer and also have attempted to prevent cooler ambient air from leaking into the throughdryer during use. In order to prevent leaks, throughdryers have been equipped with internal seals and baffles. The internal seals and baffles have been placed, for instance, adjacent to an open end of the drying cylinder, where the drying cylinder is not covered by the hood.

Although internal baffles have shown to be somewhat effective at sealing the throughdryer, cool air still becomes entrained in the drying cylinder, which typically has a substantial thickness. This carryover of air corresponding to the

thickness of the drying cylinder is commonly referred to as "shell dump". As the drying cylinder rotates, cool ambient air is drawn into the throughdryer reducing the efficiency of the process. Thus, a need currently exists for a system and process for minimizing shell dump.

Summary of The Invention

In general, the present invention is directed to a system and process for through-air drying paper webs, mainly tissue webs. For example, in one embodiment, the present invention is directed to an apparatus for drying a tissue web that comprises a through-air dryer. The through-air dryer includes a porous drying cylinder configured to permit gas flow therethrough and a hood surrounding a portion of the drying cylinder leaving an open free end. A throughdrying fabric is wrapped around the drying cylinder from an upstream point to a downstream point. The throughdrying fabric may be guided around the drying cylinder, for instance, by an upstream guide device and a downstream guide device.

In accordance with the present invention, the apparatus further includes an external baffle positioned over the open free end of the drying cylinder. In one embodiment, the external baffle comprises at least 2 plates. The plates are connected together in a manner that permits thermal expansion of the baffle. The external baffle shields the open free end of the drying cylinder from external air, thus minimizing shell dump.

In one embodiment, the plates that comprise the external baffle are connected by a connection device. At least one of the plates defines a slot that surrounds the connection device that permits relative movement of the plates. For example, the plates of the baffle may be connected in a manner such that the plates are allowed to slide over one another when undergoing thermal expansion. In one embodiment, the external baffle may be used in connection with an internal baffle positioned within the drying cylinder.

In general, the external baffle extends from the downstream point to the upstream point of the throughdrying fabric without contacting the fabric. In order to place the baffle as close as possible to the throughdrying fabric, each end of the baffle may have an adjustable length for positioning the external baffle appropriately. Each end of the baffle may also be coated with an anti-friction coating, such as a TEFLON fluoro-carbon coating, should contact occur between

the baffle and the fabric. In one embodiment, the ends of the baffle are positioned so as to overlap with the ends of the hood surrounding the drying cylinder.

In accordance with the present invention, the apparatus can also include a baffle support for positioning the external baffle adjacent to the drying cylinder. The baffle support can be in fluid communication with a cooling system configured to cool the baffle support. By cooling the baffle support, the baffle support is capable of maintaining the ends of the baffle in a fixed position during thermal expansion of the baffle.

In one embodiment, the baffle support may include a plurality of hollow support elements spaced along the external baffle. The support elements may be in fluid communication with each other for receiving a cooling fluid. The cooling system used to cool the baffle support may include a cooling fluid source in communication with at least one cooling fluid channel that is formed in the baffle support. The cooling fluid may be, for instance, a liquid or a gas, such as water or air.

In one embodiment, the apparatus of the present invention may be configured such that the throughdrying fabric conveys the tissue web through the through-air dryer without contacting any papermaking rolls. Contact with a papermaking roll may damage the tissue web or create pinholes.

Brief Description of the Drawings

A full and enabling disclosure of the present invention, including the best mode thereof to one skilled in the art, is set forth more particularly in the remainder of the specification, including reference to the accompanying figures, in which:

Figure 1 is a side view of one embodiment of a papermaking system in accordance with the present invention;

Figure 2 is a side view of one embodiment of a through-air dryer made according to the present invention;

Figure 3 is a perspective view of one embodiment of an external baffle for use with a through-air dryer in accordance with the present invention;

Figure 4 is a side view of the external baffle illustrated in Figure 3;

Figure 5 is a perspective view of another embodiment of an external baffle made in accordance with the present invention;

Figure 6 is a side view of the external baffle illustrated in Figure 5; and

Figure 7 is a perspective view of another embodiment of an external baffle made in accordance with the present invention.

Repeated use of reference characters in the present specification and drawings is intended to represent the same or analogous features or elements of the invention.

Detailed Description

It is to be understood by one of ordinary skill in the art that the present discussion is a description of exemplary embodiments only, and is not intended as limiting the broader aspects of the present invention.

In general, the present invention is directed to an improved system and process for through-air drying paper webs, particularly tissue webs. More particularly, the efficiency of a through-air dryer is improved according to the present invention by placing an external baffle adjacent to an open free end of a drying cylinder contained in the through-air dryer. The external baffle shields the open free end of the drying cylinder from external air. In this manner, ambient air is prevented from being entrained in the drying cylinder as the drying cylinder rotates. By preventing ambient air from entering the drying cylinder, the through-air dryer operates more efficiently reducing the energy requirements needed to dry a tissue web.

For purposes of illustration, for instance, one embodiment of a papermaking process made in accordance with the present invention is shown in Figure 1. As illustrated, the system includes a head box **10** which injects and deposits a stream of an aqueous suspension of papermaking fibers between a first forming fabric **12** and a second forming fabric **14**. The forming fabric **14** serves to support the newly-formed wet web **16** downstream in the process as the web is partially dewatered to a consistency of about 10 dry weight percent. Additional dewatering of the wet web **16** can be carried out, such as by vacuum suction, using one or more vacuum boxes **18**. As shown, the vacuum box **18** is positioned below the forming fabric **14**. The vacuum box **18** applies a suction force to the wet web thereby removing moisture from the web.

From the forming fabric **14**, the wet web **16** is transferred to a transfer fabric **20**. The transfer may be carried out using any suitable mechanism. As shown in

Figure 1, in this embodiment, the transfer of the web from the forming fabric **14** to the transfer fabric **20** is done with the assistance of a vacuum shoe **22**.

In one embodiment, the web **16** may be transferred from the forming fabric **14** to the transfer fabric **20** while the transfer fabric **20** is traveling at a slower speed than the forming fabric **14**. For example, the transfer fabric may be moving at a speed that is at least 5%, at least 8%, or at least 10% slower than the speed of the forming fabric. This process is known as "rush transfer" and may be used in order to impart increased machine direction stretch into the web **16**.

From the transfer fabric **20**, the tissue web **16** is transferred to a throughdrying fabric **24** and carried around a drying cylinder **26** of a through-air dryer generally **28**. As shown, the through-air dryer **28** includes a hood **30**. Hot air used to dry the tissue web **16** is created by a burner **32**. More particularly, a fan **34** forces hot air created by the burner **32** into the hood **30**. Hood **30** directs the hot air through the tissue web **16** carried on the throughdrying fabric **24**. The hot air is drawn through the web and through the drying cylinder **26** which is perforated. More particularly, the drying cylinder has a honeycomb-type structure that permits air flow through the drying cylinder but yet has sufficient integrity for use in the process.

At least a portion of the hot air is re-circulated back to the burner **32** using the fan **34**. In one embodiment, in order to avoid the build-up of moisture in the system, a portion of the spent heated air is vented, while a proportionate amount of fresh make-up air is fed to the burner **32**.

In the embodiment shown in Figure 1, heated air travels from the hood **30** through the drying cylinder **26**. It should be understood, however, that in other embodiments, the heated air may be fed through the drying cylinder **26** and then forced into the hood **30**.

While supported by the throughdrying fabric **24**, the tissue web **16** is dried to a final consistency of, for instance, about 94% or greater by the through-air dryer **28**. The tissue web **16** is then transferred to a second transfer fabric **36**. From the second transfer fabric **36**, the dried tissue web **16** may be further supported by an optional carrier fabric **38** and transported to a reel **40**. Once wound into a roll, the tissue web **16** may then be sent to a converting process for being calendered, embossed, cut and/or packaged as desired.

In the system and process shown in Figure 1, only a single through-air dryer **28** is shown. It should be understood, however, that the system may include a plurality of through-air dryers if desired. For example, in one embodiment, a pair of through-air dryers may be arranged in series. One through-air dryer may be for partially drying the web while the second through-air dryer may be for completing the drying process.

Referring to Figure 2, an isolated and enlarged view of the through-air dryer **28** is shown. As illustrated, the hood **30** surrounds a substantial portion of the drying cylinder **26**. As shown in Figures 1 and 2, however, the hood **30** leaves an open free end of the drying cylinder **26** that remains uncovered. This open free end of the drying cylinder **26** generally also corresponds to the portion of the drying cylinder that is not wrapped by the throughdrying fabric **24**.

In the past, in order to prevent cooler, ambient air from entering the drying cylinder, through-air dryers included internal baffles and seals to prevent cool outside air leaking in. For example, as shown in Figures 1 and 2, the through-air dryer **28** includes an internal baffle **42** positioned adjacent the open free end of the drying cylinder **26**. Although internal baffles, such as baffle **42**, are effective at preventing air from directly entering the drying cylinder **26**. Air, however, may still become entrained in the drying cylinder **26** as it rotates due to the thickness of the cylinder. Specifically, air becomes entrained in the drying cylinder and, as the drying cylinder rotates, the air is allowed to enter into the center area of the cylinder. This carry over of air corresponding to the thickness of the cylinder is commonly referred to as a shell dump. In some circumstances, the air entering the drying cylinder due to shell dump can be up to as much as 10% of the total air flow. The cooler air that enters the drying cylinder during shell dump adversely affects the overall efficiency of the through-air dryer **28**.

Thus, in accordance with the present invention, the through-air dryer **28** is equipped with an external baffle **50** as shown in Figures 1 and 2. As illustrated, the external baffle **50** is placed on the outside of the drying cylinder **26** adjacent to the open free end. The external baffle **50** extends from an upstream point of the throughdrying fabric to a downstream point of the throughdrying fabric. For most applications, however, the baffle does not contact the throughdrying fabric. The external baffle **50** prevents air from being entrained in the drying cylinder as the

drying cylinder rotates. Inclusion of the baffle **50** can significantly increase the overall efficiency of the through-air dryer **28**.

In one embodiment, the external baffle **50** as shown in Figures 1 and 2 may be used in conjunction with the internal baffle **42**. When used in conjunction with the internal baffle **42**, the through-air dryer **28** contains two levels of protection for preventing ambient air from infiltrating the system.

In other embodiments, however, the external baffle **50** may be used to replace the internal baffle **42**. By replacing the internal baffle, the construction of the through-air dryer becomes simplified. For instance, internal supports needed to support the internal baffle are no longer necessary.

Referring to Figures 3 and 4, one embodiment of an external baffle **50** is shown. In general, the external baffle **50** includes a plurality of baffle plates connected to a baffle support system. The baffle support system maintains the baffle in correct position.

For instance, in the embodiment shown in Figures 3 and 4, the external baffle includes a first baffle plate **52** and a second baffle plate **54**. A baffle support generally **56** includes a plurality of support elements **58**, **60** and **62** that are connected to the baffle plates. In this embodiment, each support element is connected to a connection device **66**, **68** and **70** which further connect the baffle support **56** to the baffle plates **52** and **54**. In particular, the connection devices connect to the baffle plates **52** and **54** where they intersect.

During operation of the through-air dryer **28**, the external baffle **50** increases in temperature. For example, through-air dryers are typically operated at temperatures of from about 200° F to about 500° F. During heating of the external baffle, the present inventors have recognized that the baffle, in most applications, will undergo thermal expansion. During thermal expansion, the external baffle **50** may change position and contact either the throughdrying fabric or the drying cylinder. In order to correct this problem, the external baffle **50** is designed to maintain the same seal clearance with the throughdrying fabric independent of operating temperature. Since all expansion takes place between the supports **58**, **60** and **62**, movement of the baffle at the critical juncture between the extremities of the plates **52** and **54** is minimized, reducing the risk of contact between the plates and the fabric and the dryer surface. For example, the external

baffle **50** as shown in Figures 3 and 4 is made out of a plurality of plates which are movable relative to one another when undergoing thermal expansion. Further, the baffle plates **52** and **54** are connected to the baffle support **56** which is maintained at ambient temperature. During heating of the baffle **50**, the plates **52** and **54** are permitted to slide over each other, while the baffle support **56** remains at ambient temperature and continues to support the baffle in the same location.

For example, in order to permit thermal expansion of the baffle, the baffle plates **52** and **54** are capable of sliding over each other along the center of the baffle where the connection devices **66**, **68** and **70** are located. As shown in Figure 3, for example, at least one of the baffle plates defines a slot through which the connection devices extend. In Figure 3, baffle plate **52** defines slots **74**, **76** and **78**. The slots permit the baffle plate **52** to slide over the baffle plate **54** in the machine direction during thermal expansion. Baffle plate **54** can similarly include slots if desired. As also shown in Figure 3, the baffle plates **52** and **54** are held on the connection devices **66**, **68** and **70** by retaining rings **82**, **84** and **86**. The retaining rings can be, for instance, threaded nuts or any other suitable device.

The baffle support **56** holds the baffle plates **52** and **54** in position, even during thermal expansion. The baffle support also prevents the baffle plates from being drawn against the drying cylinder during operation of the through-air dryer **28**. In particular, when the through-air dryer is operating, a suction force may develop around the drying cylinder which may have a tendency to draw the baffle towards the cylinder.

As described above, the slots **74**, **76** and **78** permit the baffle plates **52** and **54** to move relative to one another in the machine direction. As shown in Figure 3, similar slots **75** and **77** may be included on the baffle support for permitting thermal expansion in the cross machine direction. In Figure 3, the slots **75** and **77** are formed integral with the support elements **58** and **62**. In an alternative embodiment, however, the slots **75** and **77** may be formed into the baffle plates themselves. Thermal expansion takes place in the cross machine direction due to the difference in temperature between the baffle plates and the baffle support. To prevent buckling of the plate, or corrugations of the plates, allowances may be provided in the machine direction by slots **74**, **76** and **78** and in the cross machine direction by slots **75** and **77** at the extremities of the plate. The plate is fixed on

the center support **60**, which locates the plate on the tissue machine. Through the system of the present invention, the baffle plates are free to expand in both the machine direction and the cross machine direction without buckling and contacting the through-air dryer, the fabric, or the rolls while maintaining a seal.

In order to maintain the baffle plates **52** and **54** in position during thermal expansion, the baffle support **56** is connected to a cooling system for maintaining the baffle support at ambient or cooler temperatures. For example, in the embodiment shown in Figure 3, each of the support elements **58**, **60** and **62** are hollow or contain appropriate cooling fluid channels. Each of the support elements **58**, **60** and **62** are in fluid communication via a cooling conduit **90**. The cooling conduit **90** is connected to a cooling fluid source which circulates a cooling fluid throughout the baffle support. The cooling fluid may be, for instance, ambient air, another suitable gas, water, or any other suitable liquid. By maintaining the baffle support **56** at ambient temperature, the baffle support maintains the ends of the baffle plate in a fixed position in order to prevent the baffle plate from contacting the throughdrying fabric or other parts of the through-air dryer.

In general, the baffle plates **52** and **54** may be made from any suitable material. For example, the baffle plates may be made from a metal, such as steel. Further, the external baffle **50** may include more than 2 baffle plates as shown in Figure 3.

In an alternative embodiment, the external baffle **50** may comprise a single baffle plate. For example, if a material is used that has a low thermal expansion coefficient, then a single plate may be used. Alternatively, a single plate may also be designed if the temperature difference between the plate and the baffle support in conjunction with the thermal expansion coefficient of the plate are accounted for. For example, if the plate and the baffle support are made from the same material, only the relative temperature differences between the two structures must be accounted for. When dissimilar materials are used, however, the thermal expansion coefficient and the temperature difference must both be taken into account. In accordance with the present invention, the baffle plate may be made from a material having a lower amount of thermal expansion and may be used in conjunction with a baffle support that is maintained at a temperature that is always

within a preset temperature range relative to the baffle plate in order to minimize the effects of thermal expansion.

Referring to Figures 5 and 6, another embodiment of an external baffle generally **50** made in accordance with the present invention as shown. Like reference numerals have been used to indicate similar elements. For instance, the baffle **50** includes a first baffle plate **52** and a second baffle plate **54**. The plates **52** and **54** are connected to a baffle support **56**. The baffle support **56** is connected to a cooling system for maintaining the baffle support at lower temperatures.

In this embodiment, the external baffle **50** further includes adjustable ends. In particular, the baffle **50** includes a first end segment **92** and a second end segment **94**. The end segments **92** and **94** have an adjustable position with respect to the baffle plates. In particular, the end segments **92** and **94** telescope inward and outward for allowing the external baffle **50** to be precisely positioned with respect to the drying cylinder **26**, the throughdrying fabric **24**, and the hood **30**. In this manner, the ends of the baffle **50** may be positioned as close as possible to the throughdrying fabric **24** without contacting the fabric. For example, for many applications, the ends of the baffle may be placed within about ½ inch of the throughdrying fabric at the upstream end and at the downstream end of the fabric. Further, in one embodiment, the ends of the baffle **50** may also overlap with the ends of the hood **30**. By having the hood **30** and the baffle **50** overlap, a continuous seal is provided around the entire circumference of the drying cylinder **26**.

In the embodiments shown in Figures 5 and 6, the external baffle **50** includes single end segments **92** and **94** positioned on each side of the baffle. It should be understood, however, that further end segments may be included in the construction in order to permit greater adjustment capabilities. For instance, multiple end segments may be included with the baffle to provide a telescoping effect.

Referring to Figure 7, another embodiment of an external baffle generally **50** made in accordance with the present invention is shown. Again, like reference numerals have been included to represent similar elements. The external baffle **50** as shown in Figure 7, includes a first baffle plate **52** and a second baffle plate

54. The first baffle plate **52** is connected to a first end segment **92** and the second baffle plate **54** is connected to a second end segment **94**. In this embodiment, however, each of the end segments **92** and **94** include an anti-friction coating **96**. The anti-friction coating **96** is to prevent baffle wear and fabric wear should the baffle contact the throughdrying fabric **24** when positioned adjacent to the drying cylinder **26**. The anti-friction coating can be made from any suitable material. The particular material chosen may depend upon the material that is used to form the end segments **92** and **94**.

In one embodiment, for instance, the anti-friction coating **96** may be made from a fluoro-carbon material. Commercially available flouro carbon materials that may be used in the present invention, for instance, are sold under the trade name TEFLON by Dupont.

These and other modifications and variations to the present invention may be practiced by those of ordinary skill in the art, without department from the spirit and scope of the present invention, which is more particularly set forth in the appended claims. In addition, it should be understood that aspects of the various embodiments may be interchanged both in whole or in part. Furthermore, those of ordinary skill in the art will appreciate that the foregoing description is by way of example only, and is not intended to limit the invention so further described in such appended claims.